



# Vulnerability Factors and Effectiveness of Disaster Mitigation Measures in the Bangladesh Coast

Md. Nazir Hossain<sup>1</sup> · Shitangsu Kumar Paul<sup>2</sup>

Received: 12 October 2017 / Accepted: 8 January 2018 / Published online: 13 January 2018  
© Springer International Publishing AG, part of Springer Nature 2018

## Abstract

The major objective of this paper is to identify the vulnerability factors and examine the effectiveness of disaster mitigation measures undertaken by individuals, government and non-government organisations to mitigate the impacts of cyclones in the Bangladesh coast experiencing from Cyclone Aila. The primary data were collected from two villages of southwestern coastal areas of Bangladesh using questionnaire survey and interviews of the key informants. The data were analysed using the descriptive and inferential statistics. This paper reveals that the disaster management measures have a significant role to lessen the impacts of the cyclonic event, especially in pre-disaster preparedness, cyclone warning message dissemination, evacuation and post-disaster rehabilitation. The households, who have access to shelter, find weather forecast regularly and adopted pre-disaster awareness measures are relatively less susceptible to hazard's impacts. The disaster management measures undertaken by individuals and GOs and NGOs help coastal people to save their lives and property from the negative impacts of cyclones. The analysis shows that the NGOs' role is more effective and efficient than the GOs in cyclone disaster management. This paper identifies distance to shelter, participation in disaster training, efficient warning, etc. as the influential factors of vulnerability cyclones. The analysis finds the households as less affected who have adopted disaster preparedness measures. However, this paper concludes that the effective and proper disaster management and mitigation measures are very crucial to shield the lives and properties of the Bangladeshi coastal people.

**Keywords** Vulnerability factors · Disaster mitigation · Cyclone impacts · Cyclone Aila · Bangladesh

## 1 Introduction

Bangladesh is identified as the most cyclone-prone country in the world, which experienced above 36 cyclones since 1970 ensuing over 450,000 deaths and enormous economic losses (DDM 2009). A severe cyclone hits the country every 3 years on an average (DDM 2009; Dasgupta et al. 2010). Moreover, the frequency of natural hazards has been increased significantly over the last decades mostly in the Bangladesh coast which is assumed as the impact of climatic change (IPCC 2007; Karim and Mimura 2008). However,

there are a number of disagreements about the increasing frequency of cyclones due to climate change (Bengtsson et al. 2007; Knutson et al. 2010). The last severe Cyclone Aila struck the coastline of southwestern Bangladesh and eastern coast of the West Bengal of India on May 25, 2009 with a deadly 3–4 m high storm surge (Saha 2015). About 190 deaths, 7100 injuries and vast damages of property were the immediate impacts of that cyclone (DDM 2009; IFRC 2010). The population along with the infrastructure, agriculture, livestock and economic development is at a high-risk situation due to the low-lying areas of Bangladesh coast, which is frequently susceptible to cyclones (Alam 2017; Mallick et al. 2017). Therefore, the cyclone induced disaster mitigation is the main concern in the country. However, Bangladesh Red Crescent Society (BDRCS) and the Ministry of disaster management and relief (MoDMR) jointly operate a well-designed Cyclone preparedness programme (CPP) in the coastal districts of the country. The CPP has 55,260 dedicated volunteers spread over 3684 units of 350 unions of the 13 coastal districts in Bangladesh (CPP 2017).

✉ Md. Nazir Hossain  
nazirswapon@gmail.com; nazir\_swapon@yahoo.com  
Shitangsu Kumar Paul  
shitangsuk@yahoo.com

<sup>1</sup> Office of the Deputy Commissioner, Kishoreganj 2300, Bangladesh

<sup>2</sup> Department of Geography and Environmental Studies, University of Rajshahi, Rajshahi 6205, Bangladesh

Besides, the Storm warning centre (SWC) of Bangladesh meteorological department (BMD) prepares the weather forecasts and warnings, and CPP disseminates the warnings to coastal people (BMD 2017). The improved cyclone warning system and relocation of people before the imminent cyclones have become very effective in reducing the human casualty during the cyclone Sidr in 2007 and cyclone Aila (Paul and Routray 2010). During the cyclone in 2007, 2009 and also in 1991 or 1997 millions of coastal people saved their life by seeking refuge in nearby cyclone shelters as they have received proper warning message (Karim and Mimura 2008). The whole government body including the army, the navy, the air force and the relevant departments were heavily involved in the process. In addition, construction of 3500 cyclone shelters and afforestation of the coastal areas through coastal greenbelt project have been completed (CPP 2017). In association with the international development partners and NGOs, Bangladesh government has initiated a number of measures since 1960 to minimize the human casualties and property damage due to cyclone induced disaster. Besides, a good number of NGOs are also functioning in the coastal areas to lessen the human vulnerability and to improve the resilience of coastal community. Conversely, due to the top-down approaches of Bangladesh government, the pre-disaster preparedness, during-disaster rescue operation, and post-disaster relief operation and long-term rehabilitation processes appeared as less effective in many cases (Paul and Routray 2010; Islam et al. 2017). However, the aspects of coastal peoples' vulnerability, arises from various physical, social, economic, and environmental factors (Alwang et al. 2001). Such vulnerability entails isolated and scattered settlement pattern, settlements along the embankment, lack of sufficient cyclone shelters, inadequate transports to move shelters, lack of alternative skills excluding fishing and agriculture, rapid spread of unprotected settlements in hazardous places, late responses to early warning, lack of awareness, and lack of strong resilience capacity (Hossain 2015). However, the elements of vulnerability to disaster remain within the community that stimulate the hazards and make a favorable atmosphere for damaging disaster (Alam 2017). To reduce the impacts of cyclone induced disaster physical and socio-economic vulnerability have to be removed first. Without vulnerable condition natural hazard will not appear as disaster. In this case defensible capacity building of community as well as long-term preparedness and effective early warning system are very crucial for reducing the losses of lives and property (Roy et al. 2015). Therefore, an attempt has been made in this study to examine the effectiveness of disaster mitigation measures undertaken by individuals, GOs and NGOs to minimize the impacts of cyclones in the coastal areas of Bangladesh. It examines how the existing disaster mitigation measures act upon with existing vulnerable factors and what sort of adjustment could

be done to adapt with changing environment in the coastal areas of Bangladesh.

## 2 Literature Review

Numerous studies have focused on vulnerability to climatic changes and natural hazards (e.g. Adger 2006; Emrich and Cutter 2011; Dewan 2013; Islam et al. 2016, 2017). A number of studies have emphasized on the technical aspect and numerical modeling of tropical cyclone impacts (for example; Islam and Peterson 2008; Karim and Mimura 2008; Roy and Kovordányi 2012; Tasnim et al. 2015; Hoque et al. 2016, 2017b, 2018). Hoque et al. (2017a) systematically reviewed the researches on tropical cyclone disaster management using remote sensing and spatial analysis techniques. Most of the existing literature defines disaster as a result of the combination of the defencelessness to a hazard, the circumstances of vulnerability that are present and insufficient capacity to cope with the impending adverse consequences (e.g. Shoaf and Rotiman 2000; Adger 2006). It is the interaction of two opposing forces; those process generating vulnerability on one side and the natural hazard event on other (Blaikie et al. 2014). Vulnerability implies some risk combined with the level of societal and economic liability, and the capacity to cope with the resulting incident (Adger 2006; Proag 2014). Proag (2014) also defined vulnerability as the degree to which a system, or part of a system, may respond adversely to the hazards. It is the initial grounds of disaster, which is the function of susceptibility to exposure and coping capacity of the people to reduce the risk at a certain time (Blaikie et al. 2014). Few studies have investigated thoroughly the background factors of vulnerability to cyclones (Mohiuddin and Latif 2015; Saha 2015); causes, consequences and mitigation of cyclone induced disaster (Ali 1996; Paul 2009; Mallick and Vogt 2013) and cyclone shelters' suitability (Mallick 2014) and coastal settlements, livelihood and migration pattern (Mallick et al. 2017; Quader et al. 2017). Besides, Webster et al. (2005), Bengtsson et al. (2007), Elsner et al. (2008) and Knutson et al. (2010) justify the increasing propensity of frequency and intensity of tropical cyclone in warming climatic environment. Similarly, Hoque et al. (2018) depicts the risks of the cyclone for present and future climate change scenarios using geospatial techniques. Correspondingly, a number of papers also have been written focusing community response and coping strategies (Paul and Routray 2010; Islam et al. 2017), influencing factors (Hossain 2015), cyclone forecast and warning dissemination (Roy et al. 2015) and preparedness aspects of cyclone disaster (Mallick and Vogt 2013). Although many studies have been conducted in Bangladesh on cyclones but the thorough and exhaustive study on the role of vulnerability factors and effectiveness of disaster

mitigation measures in coastal Bangladesh is just about limited. Therefore, an attempt has been made in this study to examine the role vulnerability factors effectiveness of disaster management and mitigation measures undertaken by individuals, GOs and NGOs to minimize the impacts of cyclones in the Bangladesh coast.

### 3 Study Area and Methodology

The study was carried out in two villages of southwestern coast in Bangladesh and both villages were severely affected by Cyclone Aila. Of the two villages, the Gabura is in Shyamnagar upazila of Satkhira district and Golkhali in Koyra upazila of Khulna district (Fig. 1). Geographically, both villages are part of islands, which are edged by three giant rivers i.e., *Kholpetua*, *Kobadak* and *Shakbaria*. Both are the south-most settlements on the southwestern coast of Bangladesh before the Sundarbans (Mallick et al. 2017). The villagers are predominantly dependent on the resources of the Sundarbans, and fishing is the primary sources of livelihood of the communities. The primary data were collected in 2013 through the household questionnaire survey, interview with key informants and field observations. Following the simple random sampling procedure, 292 households were selected

as a sample of 1086 households from the villages assuming 95% confidence level, and samples from both villages were in proportion (Yamane 1967). The descriptive and inferential statistics were used to analyse data. With the aim of examining the association and dependency of the different variables significant test (e.g. Chi square,  $\chi^2$ ), weighted average index (WAI), percentage along with cross-tabulation and other quantitative and qualitative techniques were followed. Besides, Geographic information system (GIS) based mapping techniques were used to delineate the service area.

### 4 Results and Discussion

This study examines the effectiveness of disaster mitigation measures based on the association between household's response to mitigation measures and household's causalities and damages caused by the Cyclone Aila. Several factors, such as death, injury, post-cyclone illness and losses of houses, household goods, livestock and poultry have been selected based on impact assessment in the study villages and review of existing literature on cyclone impacts to find out the relationship with undertaken disaster management measures (Adger 2006; DDM 2009; CRF 2010; IFRC 2010; Alam 2017).

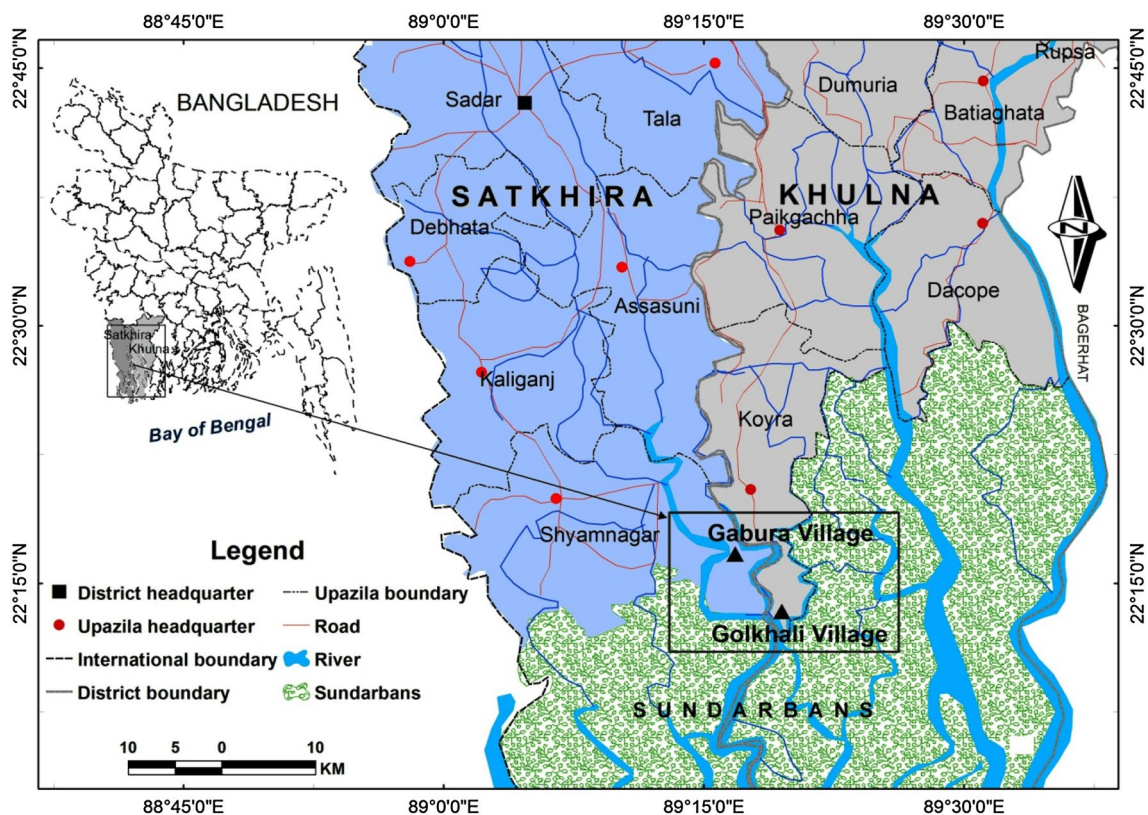


Fig. 1 Location map of the study area (Source: authors)



#### 4.1 Cyclone Shelter And Population of the Area

The total population of Gabura and Golkhali village are 3073 and 2863, respectively. During the field survey, the population was about 4000 in Gabura and 3500 in Golkhali village; as stated by the local Union parishad. There are two multipurpose cyclone shelters in the villages (Fig. 2). Usually, the capacity of the shelters is 850. While the total number population of the villages is roughly four times larger than the capacity of shelters. Moreover, there is no separate space for women in both cyclone shelters. Therefore, women are often reluctant to go to shelter during cyclonic hazard (Adger 2006; Alam 2017). Based on

the key informant interviews it reveals that the Gabura needs at least three more and Golkhali needs two more cyclone shelters to accommodate all vulnerable families of the villages. During the cyclone, the shelter becomes filled up with local people living close to the shelters. Therefore, most of the distant people cannot find space in the shelter because of insufficient capacity. The shelter service is limited to the people located within 1 km from its location (Fig. 3). Outlying people cannot get shelter because space is occupied before their arrival. Therefore, they are strained to reside in unsafe places. In this regard, respondents in both villages demand more cyclone shelters nearby their house to accommodate the vulnerable inhabitants during the hazard.



Fig. 2 a Multi-purpose cyclone shelter and b community clinic cum cyclone shelter in the study area (Source: authors)

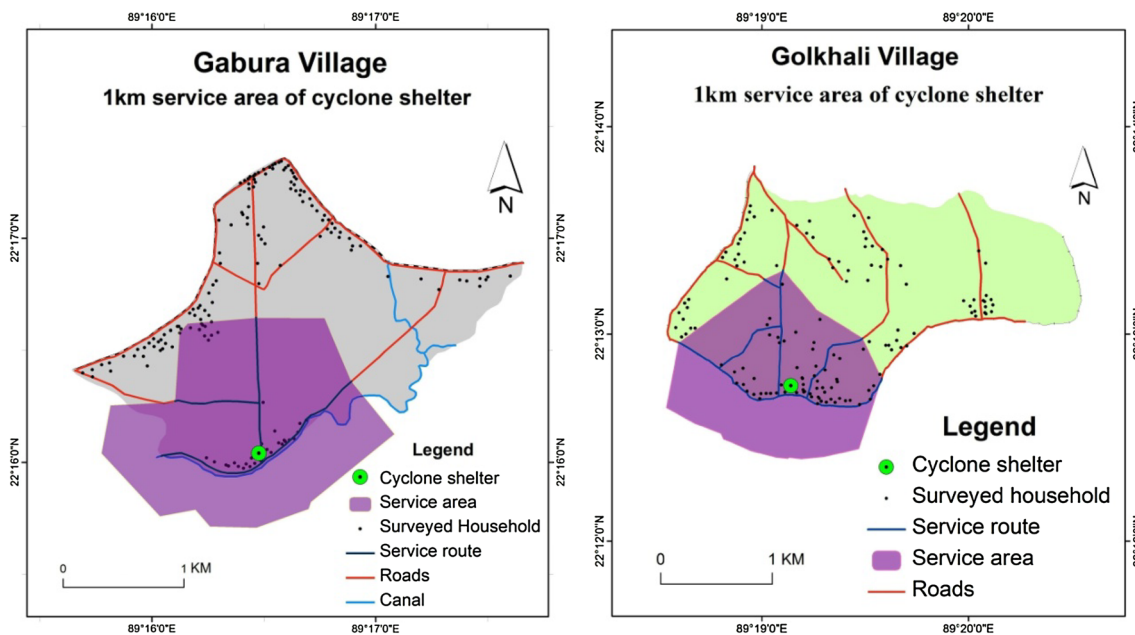


Fig. 3 1 km service area of present cyclone shelters in the study villages (Source: authors)

## 4.2 Distance to Cyclone Shelter

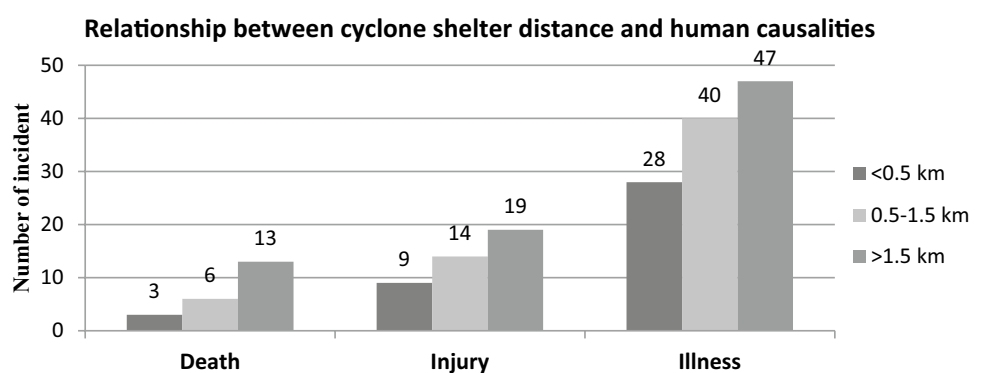
Two multipurpose cyclone shelters are available in the two villages. The number of cyclone shelters is very insufficient in terms of the number of population of villages. Although the 2/3 km is not long distance during normal time, in case of rapid storm surge followed by rainfall, the distance seems too long to reach the shelters. About one-third of the respondents of Gabura village live in more than 2.0 km away from cyclone shelter. Therefore, these peoples are undoubtedly exposed to cyclone while all respondents of Golkhali village live within 0–2 km distance and remain relatively safer than Gabura village. Hence, the respondents of Gabura village are more vulnerable to cyclone than the respondents of Golkhali village. Although the accessibility to cyclone shelter also depends on other factors e.g. capacity of cyclone shelter, number of family member, mode of transport to reach cyclone shelter, etc. However, in general, increasing distance from cyclone shelter makes inhabitants more vulnerable to cyclone events. The study finds that cyclone-related casualty increases with the increasing distance to cyclone shelters from the house. Less number of mortality is found among the households located within 0.5 km from cyclone shelter. On the contrary, mortality increases among the households located in more than 1.5 km from cyclone shelter. The total number of deaths was 22, out of which 13, 6 and 3 were in the households living more than 1.5 km, within 0.5–1.5 km and less than 0.5 km distance from cyclone shelter, respectively (Fig. 4). Such finding is consistent with Shoaf and Rotiman (2000) and Paul et al. (2011) that smaller and denser cyclone shelters located within minimum 2 km from household could significantly reduce cyclone-related mortality. Most cases cyclone-related death takes place due to drowning in surge water while people move towards cyclone shelter. The study found that human injury due to cyclone significantly varies according to the shelter distance from houses. Relatively higher numbers of households having injuries are found in the distant households than the nearest households. Cyclone-related

injury also takes place while people move towards cyclone shelter. Similarly, incidences of illness significantly vary according to the shelter distance because the people who have taken protection from cyclone shelter faced relatively fewer diseases than others.

## 4.3 Condition of Road and Embankments

Connectivity to the road is a precondition for successful evacuation and rescue operation during-disaster period and post-disaster relief operations. The improved road communication networks accelerate the rate of evacuation and rescue operations. The roads and path of the study areas are completely unpaved and narrow. Almost all embankments are used as the road. The conditions of roads are very miserable in both villages which remain completely inaccessible to motorized vehicles. The miserable conditions of the roads and embankments undoubtedly exaggerated the negative impacts of cyclonic hazards. The connecting roads between people's house to cyclone shelter are very poor and unpaved. The study reveals that 36% of respondents depend on walkway/footpath to go to shelters. The earthen embankments are built to protect the coastal communities from storm surge and tidal/coastal flooding. Both the study villages are protected by embankments, constructed by East Pakistan water and power development authority (EPWAPDA) during 1961–1978 under the Coastal embankment project (CEP). The embankments are intended to defend the nearby land from tidal flooding but cannot prevent coastal inundation and damage from tidal bores. Due to lack of maintenance of embankment on a regular basis, the width of the embankments is decreasing and become deteriorated day by day. Moreover, some peoples cut or penetrate pipes to the embankment to bring saline water for cultivation of shrimps that further weakening the embankment. The embankments are severely narrow and unprotected in many places which are incapable to protect surges or tidal bores.

**Fig. 4** Relationship between cyclone shelter distance and associated losses (Source: authors)



#### 4.4 Mode of Transport to Reach Cyclone Shelter

The transport used to reach to the cyclone shelter, is a vital factor in emergency period for accessing shelter. There is no motorized transport system in the study villages because of road and path are made up of mud or footpath and unpaved. The existing literature reveals that most of the people died or injured on the way to shelter during cyclones and tidal surges (Ali 1996). About all of the respondents (97.6%) go shelter on foot and only 2.4% have used motorized transport such as motorbikes. The study finds that cyclone-related mortalities and injuries are significantly higher among the households had dependent on walking to reach cyclone shelter during the cyclonic hazard. It reveals that among the 22 reported deaths in the study villages, all were the member of the households had relied on walking to reach to the cyclone shelter. Majority of the respondents (94.2%) expressed a negative opinion in case of the transport system and are very dissatisfied with local government activities in this regard. The lack of preparedness measure such as proper transport system and accessibility in this remote area has made it even more vulnerable to cyclonic hazards. It is not only a hindrance to reach shelter, but also a barrier during disaster quick evacuation and post-disaster relief operation.

#### 4.5 Emergency Management and Disaster-Related Training Programs

The community level emergency management committee exists in both the villages and these are also under the

coverage of the CPP. The study finds that 92.1% of respondent knows about the existence of the emergency management committee and 79.1% know about the CPP coverage in their locality. This study also finds that government and non-government organisations trained the villagers to reduce susceptibility to the cyclone and afterwards damages. The programs teach them about protecting their lives, dwellings, household assets and livestock during and post-cyclone period. More than half of respondents (55.1%) did not participate in such training programs. A number of existing studies reveal that the trained and aware people are less vulnerable to external shocks such as hazards (Paul and Routray 2010). As expected, the study reveals a significant association between participation of respondents in disaster-related training programs and rates of cyclone-related mortality, injury and illness. It reveals that deaths due to cyclone were found 90.9% of the households did not participate in disaster-related training. Perhaps this is because of the higher level of consciousness and preparedness of the household heads who participated in such training than the non-participant households. Similarly, rates of injury and post-cyclone illness are higher among the households head did not have participation in training than the households head having training (Table 1). The household head having disaster-related training is conscious and aware of the outbreak of post-cyclone water-borne diseases, and takes precautionary measures and remain relatively safer than other households. Likewise, as the training programs teach people to protect dwellings, household assets and livestock during and post-cyclone period hence damages remain less.

**Table 1** Relationship between participation in disaster-related training and associated damages

Categories of impact	Participation in disaster-related training				Total	
	No		Yes			
	HH	%	HH	%	HH	%
Human casualties						
Death	20	90.9	2	9.1	22	100.0
Injury	38	90.5	4	9.5	42	100.0
Illness	85	73.9	30	26.1	115	100.0
Damages of houses						
< Tk. 8000	50	51.0	48	49.0	98	100.0
Tk. 8000–15,000	66	53.2	58	46.8	124	100.0
> Tk. 15,000	45	64.3	25	35.7	70	100.0
Total	161	55.1	131	44.9	292	100.0
$\chi^2$ -test	$\chi^2 = 3.223$ , Sig. value = .200, $df = 2$ , $\alpha = 0.05$					
Losses of livestock and poultry						
Yes	80	58.0	58	42.0	138	100.0
No	81	52.6	73	47.4	154	100.0
Total	161	55.1	131	44.9	292	100.0
$\chi^2$ -test	$\chi^2 = 0.850$ , Sig. value = .357, $df = 1$ , $\alpha = 0.05$					

USD 1 = Tk 83 [11 December 2017]

The rate of losses of livestock and poultry is higher (58.0%) among the households head does not have disaster-related training than the household head having training (42.0%). The Chi-square test finding confirms a significant association between participation in disaster-related training and cyclone-related damages. Therefore, such finding unveils high-level vulnerability to cyclone-related causalities and damages of the households whose heads did not participate in disaster-related training and also proves such training as a crucial factor to reduce cyclone induced disaster impacts.

#### 4.6 Receiving Cyclone Forecast

The importance of the cyclone forecast and warning is widely recognized as a crucial measure to mitigate the loss of living animals and belongings caused by the cyclone disaster (Paul and Routray 2010). Nearly half of the respondents (46.2%) received warning or forecast from various sources about the imminent cyclone. These sources were mainly Radio, Television, signal flags, Megaphones and so on. In addition, deaths due to cyclone were found 21(95.5%) among the households did not receive any warning or forecast from any source about the imminent cyclone. The households who have received information about impending cyclone took precautionary measures and sought refuge to cyclone shelter to keep them relatively safer. The respondents who have received information about impending cyclone are relatively educated and conscious than those people who were not warned. Moreover, education also reveals as an important factor for capturing warning messages. Such finding is consistent with Paul and Routray (2010) that receiving cyclone

forecast could significantly reduce cyclone-related causalities. Similarly, the rate of injury is higher (85.7%) among the households were warned earlier than the households (14.3%) who were not warned. On the other hand, receiving cyclone forecast does not appear as an influencing factor of the outbreak of post-cyclone disease. The occurrence of diseases is mostly similar irrespective of forecast receivers and non-receivers. But receiving cyclone forecast appears as an influencing factor in the case losses of household goods, livestock and poultry (Table 2). Perhaps the households received cyclone forecast could able to take precautionary measures to protect their household goods and livestock. The rate of losses of livestock and poultry is higher (55.1%) among the forecast receiving households than the households did not receive forecast (44.9%). The Chi-square test result confirms a significant association between receiving cyclone forecast and cyclone-related damages. Therefore, such finding unveils higher level of vulnerability to the households did not receive forecast than the households receive forecast in terms of damage caused by the cyclone. Such finding unveils cyclone forecast as an important factor of human vulnerability to cyclone induced disaster.

#### 4.7 Access to Radio and Television

The Radio and Television are the important mass-media to receive forecast about impending hazards. In the coastal area, people's awareness and access to weather forecast also determine the level of susceptibility to cyclonic hazards (Islam et al. 2017). Lack of such devices for the people of remote coastal areas or not staying in the fishing boat in deep

**Table 2** Relationship between receiving cyclone forecast and associated damages

Categories of impact	Receiving cyclone forecast				Total	
	No		Yes			
	HH	%	HH	%	HH	%
Human causalities						
Death	21	95.5	1	4.5	22	100.0
Injury	36	85.7	6	14.3	42	100.0
Illness	58	50.4	57	49.6	115	100.0
Damages of household goods						
< Tk. 6000	50	51.0	48	49.0	98	100.0
Tk. 6000–12,000	73	58.9	51	41.1	124	100.0
> Tk. 12,000	36	51.4	34	48.6	70	100.0
Total	159	53.8	133	46.2	292	100.0
$\chi^2$ -test	$\chi^2 = 2.357$ , Sig. value = .308, $df = 2$ , $\alpha = 0.05$					
Losses of livestock and poultry						
Yes	76	55.1	62	44.9	138	100.0
No	83	52.2	71	47.8	154	100.0
Total	159	53.8	133	46.2	292	100.0
$\chi^2$ -test	$\chi^2 = 0.179$ , Sig. value = .672, $df = 1$ , $\alpha = 0.05$					

sea cannot get warning messages. An alarming fact is that more than two-thirds (70.2%) of respondents have no access to this indispensable facility. The number of death 20(90.9%) is higher among the households who had no Radio or Television set as a medium to receive cyclone forecast than the households 9.1% (2) had access to these vital facilities. As expected, the cyclone-related injury is also higher among the household had no access to such facilities 40(95.2%).

#### 4.8 Searching Interval of Weather Forecast

The study finds that more than two-thirds of total respondents (72.6%) never searching for weather forecast while 16.8% searches weather forecast sometimes such as once a week (9.6%) or twice a week (7.2%) and only 10.6% searches forecast every day (Table 3). The WAI value (0.22) also confirms the people's indifference to finding weather forecast. The main reasons of such indifference to weather forecast

are inappropriateness and vast areal context of weather forecast broadcasted through Radio/Television, inaccessibility to Radio/Television, previous experience of receiving the false warning, lack education and awareness, etc.

This study also finds that cyclone-related mortality is significantly higher among the households who never search weather forecast (86.3%). Similarly, consistent with expectations that cyclone-related injury is significantly higher among the households never searches weather forecast (76.2%) followed by sometimes (19.0%) and regularly searching for the forecast (4.8%). It also appears as an influencing factor in case of losses of livestock and poultry, and 60.9% of households who never searches weather forecast faced the losses of livestock and poultry due to cyclone and storm surge (Table 4). Similarly, Chi-square test finding unveils significant association between the searching interval of the weather forecast and cyclone-related damages. Such finding unveils relatively higher level of vulnerability of the

**Table 3** Searching interval of weather forecast

Searching interval	Gabura		Golkhali		Total	
	HH	%	HH	%	HH	%
Never	110	71.4	102	73.9	212	72.6
Once a week	17	11.0	11	8.0	28	9.6
Twice a week	11	7.1	10	7.2	21	7.2
Every 2 days	8	5.2	9	6.5	17	5.8
Everyday	8	5.2	6	4.3	14	4.8
Total	154	100.0	138	100.0	292	100.0
$\chi^2$ -test	$\chi^2 = 5.169$ , Sig. value = .270, $df = 4$ , $\alpha = 0.05$					
Weighted average index (WAI) = 0.22						
Criteria of assessment						
Highly insufficient	0.01–0.20					
Insufficient	0.21–0.40					
Moderate	0.41–0.60					
Sufficient	0.61–0.80					
Highly sufficient	0.81–1.00					

**Table 4** Relationship between searching interval of weather forecast and associated damages

Categories of impact	Searching interval of weather forecast						Total	
	Never		Sometimes		Regularly			
	HH	%	HH	%	HH	%	HH	%
Human casualties								
Death	19	86.3	3	13.7	0	0	22	100.0
Injury	32	76.2	8	19.0	2	4.8	42	100.0
Illness	45	39.2	41	35.6	29	25.2	115	100.0
Losses of livestock and poultry								
Yes	84	60.9	32	23.2	22	15.9	138	100.0
No	128	83.1	17	11.0	9	5.8	154	100.0
Total	212	72.6	49	16.8	31	10.6	292	100.0
$\chi^2$ -test	$\chi^2 = 18.354$ , Sig. value = .000, $df = 2$ , $\alpha = 0.05$							



households who never search weather forecast to cyclone-related causalities than the households who find weather forecast regularly. Besides, the households who find weather forecast regularly are usually the educated groups, hence become conscious, and adopt precautionary measures prior to the landfall of the cyclone and remain safe.

#### 4.9 Post-Cyclone Medical Assistance and Rehabilitation

People complained that after cyclone and surge, they often do not find doctors from government hospitals or health centre. About 67.5% of the respondents mentioned they did not get any medical treatment from any sources, neither government nor NGOs (Table 5). Therefore, they find that they are deprived of such emergency government facilities. People also grumbled about not having veterinary doctors in the neighborhood to provide treatment to ailing livestock.

Apart from these, hazard disrupts people's usual sources of livelihood (Quader et al. 2017). The aftermath of disaster period victims needs to recover their livelihood to earn daily bread. Quick and effective recovery from the impacts of the disaster depends significantly on how quickly livelihoods are restored. In the field survey, a large number of the respondents informed that they did not get any help or financial support to rebuild their livelihood. More than two-thirds (69.2%) of the respondents did not get any financial help from any government or non-government sources. As a result, they become further vulnerable to cyclones or other impending hazards. In the study area, a number of local people were engaged in reconstruction and repairing of roads and dam under government provided food for work (Kazer Binimoye Khaddo, Kabikha) and Test relief programmes (TRF). The local people complained about corruption and nepotism against Union parishad members

and representatives in providing Kabikha, Test relief or other livelihood generating activities. They also accused that they often need to give bribe to get such government helps. Hence, due to insecure livelihood, coastal community become more vulnerable to impending disaster.

Severe cyclone disrupts the normal agricultural activities and agricultural sectors. Most of the respondents (88.4%) mentioned that they did not get any assistance for agricultural rehabilitation from any sources. According to local inhabitants, the government should provide soft credits with 'easy terms' in the fishery sector. Farmers are generally afraid of 'too much paperwork', for which they do not seek assistance from scheduled banks. People also expressed their needs for credit to start income generating activities such as rearing livestock, fishery, poultry, etc. to secure livelihood in the post-cyclone period.

#### 4.10 Role of GOs and NGOs in Cyclone Disaster Mitigation

The study finds that the cyclone disaster mitigation activities undertaken by the government are not fully effective because of improper implementation, corruption and inefficient personals. The respondents accused that most of the planning strategies of government were not undertaken considering the opinion of local stakeholders. It reveals that about two-thirds of the respondents (43.5%) are dissatisfied, 19.5% are highly dissatisfied, 26.0% are moderately satisfied, 8.9% are satisfied and only 2.1% are highly satisfied to the role of government organisations (GOs) in cyclone disaster mitigation activities. People expect direct facilitation of government towards the establishment of the sufficient number of multi-purpose cyclone shelters in their locality and a community-based disaster management plan at union levels, which may

**Table 5** Getting emergency medical assistance and rehabilitation facilities after cyclone

Services	Gabura		Golkhali		Total	
	HH	%	HH	%	HH	%
Emergency medical services						
No	105	68.2	92	66.7	197	67.5
Yes	49	31.8	46	33.3	95	32.5
$\chi^2$ -test	$\chi^2 = 1.652$ , Sig. value = .199, $df = 1$					
Financial support to continue livelihood						
No	115	74.7	87	63.0	202	69.2
Yes	39	25.3	51	37.0	90	30.8
$\chi^2$ -test	$\chi^2 = 33.167$ , Sig. value = .032, $df = 1$ , $\alpha = 0.05$					
Support to overcome agricultural damages						
No	135	87.7	123	89.1	258	88.4
Yes	19	12.3	15	10.9	34	11.6
Total	154	100.0	138	100.0	292	100.0
$\chi^2$ -test	$\chi^2 = 0.370$ , Sig. value = .543, $df = 1$					

be implemented by the local government institutions (Islam et al. 2017).

Besides, different types of voluntary and non-voluntary national and international NGOs are working for disaster preparedness and mitigation services in the study area. Functionally important NGOs are BRAC, CARE, World Vision, Caritas, Grameen bank, ASA, Barsa, Chetana, Swadesh, Uttaran, Sushilon, Pragati, Usha, Parapar, Jubo Academy and Seeds. The NGOs are mainly working in various pre-, during and post-disaster actions. Pre-disaster measures include advocacy, public education promotions and training programs for workforces engaged in disaster management activities from the national down to the community level (Roy et al. 2015). NGOs are also involved in during disaster rescue operation and relocating people to safe places. Finally, offering post-disaster micro-credits and rescheduling previous credit payment programs for the rehabilitation of victims are included in post-disaster measures. Respondents opined that NGOs assisted them in the emergency evacuation, relief operation, post-cyclone temporary shelter and credit facilities. On the contrary, few respondents mentioned that the role of NGOs is not significant and some of them criticized their contradictory roles such as giving assistance among the members with a high rate of interest. The victims express different responses about the activities of NGOs and specifically criticized the micro-credit based NGOs. According to their opinion, after cyclones the NGOs provide them micro-credit to rebuild their livelihood, at that moment the affected people are forced to receive this loan because cyclone washed away their house and household belongings, crops and livestock. However, afterward, they had to pay this loan with a high rate of interest. Few respondents praised the voluntary NGOs, those usually give them relief and financial support without any interest. Nearly, 11.0% are highly dissatisfied, 31.5% are dissatisfied, 32.9% are moderately satisfied and 18.5% respondents are satisfied while only 6.2% are highly satisfied on NGOs' role to cyclone disaster management activities in the study area (Table 6). The Weighted Average Index values indicate that respondent's satisfaction level on NGOs' role (WAI = 0.55) is relatively better than the GOs (WAI = 0.46).

## 5 Conclusion

The study identifies that distance to cyclone shelter, participation in disaster training, efficient warning, etc. are influential factors, affecting cyclone vulnerability in the study area. Besides, disaster preparedness measures have a significant role to mitigate the adverse impacts of cyclonic hazards. The analysis reveals that the vulnerability is higher among the households in remote and scattered settlements because of increased isolation from information for improving

**Table 6** Respondent's satisfaction on GOs and NGOs' activities for cyclone disaster management

Level of satisfaction	Government organi- sations (GOs)		Non-government organisations (NGOs)	
	HH	%	HH	%
Highly dissatisfied	57	19.5	32	11.0
Dissatisfied	127	43.5	92	31.5
Moderately satisfied	76	26.0	96	32.9
Satisfied	26	8.9	54	18.5
Highly satisfied	6	2.1	18	6.2
Total	292	100.0	292	100.0
Weighted average index	0.46 (Moderately satisfied)		0.55 (Moderately satisfied)	
Criteria for assessment				
Highly dissatisfied	0.01–0.20			
Dissatisfied	0.21–0.40			
Moderately satisfied	0.41–0.60			
Satisfied	0.61–0.80			
Highly satisfied	0.81–1.00			

preparedness, disrupted traditional community networks and insufficient cyclone shelters. Conversely, the households who have taken disaster preparedness measures are less affected by cyclone's impacts. In contrast, the most affected households are those who have not adopted any disaster preparedness measures. The households in hazardous setting contain the elements of severe susceptibility to adverse external shocks. The dynamic role of GOs and NGOs also helped the people to save their lives and properties. Post-disaster medical assistance and profession-based rehabilitation should be prompt and effective considering people's needs and emergency. This paper unveils that mitigation of internal limitations of households along with disaster preparedness can lessen enormous losses and casualties due to cyclones. Such findings of this study would be helpful to examine the performance of vulnerability mitigation measures to other natural disasters such as flood, riverbank erosion and drought in other areas of Bangladesh. This paper advocates that proper early warning, construction of new cyclone shelters and proper rehabilitation programs can be effective and fruitful to lessen the impacts of the cyclone. Further initiatives are required for incorporating the measures of different organisations as well as strengthening institutional machinery through decentralization and root-level disaster mitigation planning. The activities require a huge investment in preparedness, shelter construction, institutional arrangement, policy formulation and community participation for enhanced cyclone disaster mitigation to shield the coastal inhabitants from the harsh impacts of imminent cyclones.

## References

- Adger WN (2006) Vulnerability. *Glob Environ Change* 16(3):268–281
- Alam GM (2017) Livelihood cycle and vulnerability of rural households to climate change and hazards in Bangladesh. *Environ Manag* 59(5):777–791
- Ali A (1996) Vulnerability of Bangladesh to climate change and sea level rise through tropical cyclones and storm surges. In: Erda L et al. (eds) *Climate change vulnerability and adaptation in Asia and the Pacific*. Springer, Dordrecht, pp 171–179
- Alwang J, Siegel PB, Jorgensen SL (2001) Vulnerability: a view from different disciplines. Discussion Paper Series No. 0115. Social Protection Unit, World Bank, Washington DC
- Bengtsson L, Hodges KI, Esch M, Keenlyside N, Kornbluh L, Luo JJ, Yamagata T (2007) How may tropical cyclones change in a warmer climate? *Tellus* 59(4):539–561
- Blaikie P, Cannon T, Davis I, Wisner B (2014) *At risk II: natural hazards. People's Vulnerability and Disasters*, Routledge
- BMD (Bangladesh Meteorological Department) (2017) <http://www.bmd.gov.bd/cyclone>. Accessed 10 Oct 2017
- CPP (Cyclone Preparedness Programme) (2017) <http://www.cpp.gov.bd/Home>. Accessed 11 Dec 2017
- Dasgupta S, Huq M, Khan ZH, Ahmed MMZ, Mukherjee N, Khan MF, Pandey KD (2010) Vulnerability of Bangladesh to cyclones in a changing climate: potential damages and adaptation cost. World Bank Policy Research Working Paper No. 5280. <https://ssrn.com/abstract=1596490>. Accessed 10 Oct 2017
- DDM (Department of Disaster Management) (2009) Summary of cyclonic storm “Aila”. Government of Bangladesh, Dhaka. <http://www.ddm.gov.bd>. Accessed 10 Oct 2017
- Dewan A (2013) *Floods in a megacity: geospatial techniques in assessing hazards, risk and vulnerability*. Springer, Dordrecht
- Elsner JB, Kossin JP, Jagger TH (2008) The increasing intensity of the strongest tropical cyclones. *Nature* 455(7209):92–95
- Emrich CT, Cutter SL (2011) Social vulnerability to climate-sensitive hazards in the southern United States. *Weather Clim Soc* 3(3):193–208
- Hoque MAA, Phinn S, Roelfsema C, Childs I (2016) Assessing tropical cyclone impacts using object-based moderate spatial resolution image analysis: a case study in Bangladesh. *Int J Remote Sens* 37(22):5320–5343
- Hoque MAA, Phinn S, Roelfsema C (2017a) A systematic review of tropical cyclone disaster management research using remote sensing and spatial analysis. *Ocean Coast Manag* 146:109–120
- Hoque MAA, Phinn S, Roelfsema C, Childs I (2017b) Tropical cyclone disaster management using remote sensing and spatial analysis: a review. *Int J Disaster Risk Reduct* 22:345–354
- Hoque MAA, Phinn S, Roelfsema C, Childs I (2018) Modelling tropical cyclone risks for present and future climate change scenarios using geospatial techniques. *Int J Digit Earth* 11(3):246–263
- Hossain MN (2015) Analysis of human vulnerability to cyclones and storm surges based on influencing physical and socioeconomic factors: evidences from coastal Bangladesh. *Int J Disaster Risk Reduct* 13:66–75
- IFRC (International Federation of Red Cross and Red Crescent Societies) (2010) Bangladesh: Cyclone Aila, IFRC, April 2010. [www.ifrc.org/docs/appeals/10/mdrbd004\\_ou7.pdf](http://www.ifrc.org/docs/appeals/10/mdrbd004_ou7.pdf)
- IPCC (Intergovernmental Panel on Climate Change) (2007) *Climate Change 2007: synthesis report. The Physical Science Basis*, 4th Assessment Report, Cambridge University Press, Cambridge
- Islam T, Peterson RE (2008) Tropical cyclone wind characteristics for the Bangladesh coast using Monte Carlo simulation. *J Appl Sci* 8(9):1249–1255
- Islam MA, Mitra D, Dewan A, Akhter SH (2016) Coastal multi-hazard vulnerability assessment along the Ganges deltaic coast of Bangladesh—a geospatial approach. *Ocean Coast Manag* 127:1–15
- Islam R, Walkerden G, Amati M (2017) Households' experience of local government during recovery from cyclones in coastal Bangladesh: resilience, equity, and corruption. *Nat Hazards* 85(1):361–378
- Karim MF, Mimura N (2008) Impacts of climate change and sea-level rise on cyclonic storm surge floods in Bangladesh. *Glob Environ Change* 18(3):490–500
- Knutson TR, McBride JL, Chan J, Emanuel K, Holland G, Landsea C, Sugi M (2010) Tropical cyclones and climate change. *Nat Geosci* 3(3):157–163
- Mallick B (2014) Cyclone shelters and their locational suitability: an empirical analysis from coastal Bangladesh. *Disasters* 38(3):654–671
- Mallick B, Vogt J (2013) Population displacement after cyclone and its consequences: empirical evidence from coastal Bangladesh. *Nat Hazards* 73(2):191–212
- Mallick B, Ahmed B, Vogt J (2017) Living with the risks of cyclone disasters in the South-Western coastal region of Bangladesh. *Environments* 4(1):13
- Mohiuddin M, Latif MB (2015) Housing condition of coastal area in Bangladesh: a case study of Kutubdia, Cox's Bazaar. *J Environ Sci Nat Resour* 6(1):15–20
- Paul BK (2009) Why relatively fewer people died? The case of Bangladesh's Cyclone *Sidr*. *Nat Hazards* 50:289–304
- Paul SK, Routray JK (2010) Household response to cyclone and induced surge in coastal Bangladesh: coping strategies and explanatory variables. *Nat Hazards* 57(2):477–499
- Paul BK, Rahman MK, Rakshit BC (2011) Post-Cyclone *Sidr* illness patterns in coastal Bangladesh: an empirical study. *Nat Hazards* 56(3):841–852
- Proag V (2014) The concept of vulnerability and resilience. *Proc Econ Finance* 18:369–376
- Quader MA, Khan AU, Kervyn M (2017) Assessing risks from cyclones for human lives and livelihoods in the Coastal Region of Bangladesh. *Int J Environ Res Public Health* 14(8):831
- Roy C, Kovordányi R (2012) Tropical cyclone track forecasting techniques—a review. *Atmos Res* 104–105:40–69
- Roy C, Sarkar SK, Åberg J, Kovordányi R (2015) The current cyclone early warning system in Bangladesh: providers' and receivers' views. *Int J Disaster Risk Reduct* 12:285–299
- Saha CK (2015) Dynamics of disaster-induced risk in southwestern coastal Bangladesh: an analysis on tropical Cyclone Aila 2009. *Nat Hazards* 75(1):727–754
- Shoaf KI, Rotiman SJ (2000) Public health impact of disasters. *Aust J Emerg Manag* 15(3):58–62
- Tasnim KM, Shibayama T, Esteban M, Takagi H, Ohira K, Nakamura R (2015) Field observation and numerical simulation of past and future storm surges in the Bay of Bengal: case study of cyclone Nargis. *Nat Hazards* 75(2):1619–1647
- Webster PJ, Holland GJ, Curry JA, Chang HR (2005) Changes in tropical cyclone number, duration, and intensity in a warming environment. *Science* 309(5742):1844–1846
- Yamane T (1967) *Statistics: an introductory analysis*. Harper and Row, New York